

## HR-325 Thermoset Composite Concrete Reinforcement

**Key Words:** Reinforcing Bars, Fiber Composite Bars, Dowel Bars

### Abstract

The introduction of new materials into industry requires that both the un-aged load carrying capabilities and a knowledge of the long term effects of aging must be determined before comparisons can actually be made between these new materials and materials that have been in use for decades. Studying the effects of aging in a natural real weather environment can be unrealistic if the life expectancy of this material is greater than a few years. The life expectancy of fiber composite materials can span over many tens of years, therefore, this report presents a method of accelerated aging to predict the long term capabilities of fiber composite materials. This report also looks at the possibility of using fiber composite reinforcing bars and dowels as a viable alternative to steel as concrete reinforcement.

Accelerated aging entails submersion of fiber composite materials (these fiber composite materials are cast in a concrete system) in a water solution at an elevated temperature. Two theories have been suggested for the loss in strength of fiber composite materials. First, the hot, wet environment accelerates the reaction between the glass fibers and the alkali in the concrete. A hydration product is deposited between the individual glass fibers causing them to become brittle. Second, direct attack by the alkali in the cement on the glass fibers, results in etching and pitting of the glass fibers and loss of tensile capacity. This process of strength loss (due to accelerated aging) has been compared to strength loss in real weather aging in the natural environment. Accelerated aging was used by Pilkington Brothers Limited of the United Kingdom and further testing by other experimenters has verified that accelerated aging can be used to approximate real weather aging of fiber composite materials. The results of accelerated aging on glass fibers embedded in a mortar environment (strand-in-cement test) and glass fiber reinforced concrete (GFRC) were used predict long term aging of these glass fibers.

The effects of accelerated aging on fiber composite reinforcing bars and dowel bars composed of E-glass fibers encapsulated in a vinyl ester resin matrix are presented in this report. These fiber composite specimens were cast in concrete and exposed to three different aging bath solutions (water, lime, and salt) at an elevated temperature of 140°F for nine weeks. Control (unaged) specimens were compared with aged specimens, and the effects of aging could then be observed. The aged fiber composite reinforcing bars cast in concrete specimens were tested in direct tension to determine the degradation, if any, in bond between the concrete and fiber composite material. The aged fiber composite dowel bars in concrete specimens were tested in direct shear to find the effects of accelerated aging on the shear capacity.

Degradation of uncoated E-glass fibers has been proven by other researchers to be extensive in a mortar environment due to alkali attack. Vinyl ester resin has been tested by Dow Chemical and proven to be highly resistant to chemical attack. The E-Glass/vinyl ester resin fiber composite (both dowels and reinforcing bars) have been shown through testing at Iowa State University to be highly resistant to the detrimental affects of accelerated aging and can be considered a potential substitute for steel.